

Effects of Cage Stocking Density on Egg Quality Traits in Japanese Quails

Mahmoud Salah EL-TARABANY¹  Tamer Mohamed ABDEL-HAMID¹
Hesham Hosny MOHAMMED²

¹ Department of Animal Wealth Development, Faculty of Veterinary Medicine, Zagazig University, EGYPT

² Department of Veterinary Public Health, Faculty of Veterinary Medicine, Zagazig University, EGYPT

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Abstract

This study was conducted to investigate the effects of different stocking densities on external and internal egg quality traits and to measure the phenotypic correlation coefficients between external and internal egg quality traits. Two hundred and sixteen birds of Japanese quail at 14th week of age were used in this experiment. The birds were divided randomly into three groups, 60, 72 and 84. Each group subdivided into 4 replicates, where the cages floor spaces were 200, 167 and 143 cm²/bird; respectively. The obtained results revealed that birds housed at 200 cm²/bird laid heavier egg weight (12.24 g), with significant (P<0.05) higher external quality traits, including shell weight (1.27 g), eggshell ratio (10.55%), shell thickness (0.23 mm) and egg shell density (48.70 mg/cm²). Similarly, internal quality traits, including yolk height (10.72 mm), albumen height (5.67 mm), yolk diameter (24.97 mm), yolk index (43.49%) and Haugh unit (92.77). Shell weight positively correlated with yolk height (P<0.01), albumen height (P<0.01), albumen weight (P<0.05) and haugh unit (P<0.01). It was concluded that, housing Japanese quail at low cage floor space associated with depression in external and internal egg quality traits. Moreover there is an economical hazard of housing quails at cage floor space lower than 200 cm²/bird.

Keywords: Cage, Egg quality, Stocking density, Quail

Bıldırcınlarda Kafes Yoğunluğunun Yumurta kalitesi Üzerine Etkileri

Özet

Bu çalışma değişik kafesleme yoğunluklarının iç ve dış yumurta kalitesi üzerine etkisini araştırmak, iç ve dış yumurta kalitelerinin fenotipik korelasyon katsayısını ölçmek amacıyla yapılmıştır. Çalışmada 14 haftalık toplam 216 bıldırcın kullanılmıştır. Hayvanlar rastgele olarak 3 gruba (60, 72 ve 84) ayrıldı. Her bir grup taban alanları sırasıyla 200, 167 ve 143 cm²/bıldırcın olacak şekilde ayrıca 4 tekrarlı olmak üzere ayrıldı. Çalışma bulguları sonucunda 200 cm²/bıldırcın olan grupta bıldırcınların daha ağır yumurta verdikleri (12,24 g), anlamlı derecede daha yüksek dış özellikler gösterdikleri; kabuk ağırlığı (1.27 g), kabuk oranı (%10.55), kabuk kalınlığı (0.23 mm) ve kabuk yoğunluğu (48.70 mg/cm²) belirlendi. Benzer olarak iç kalite özellikleri; yumurta sarısı yüksekliği (10.72 mm), yumurta akı yüksekliği (5.67 mm), yumurta sarısı çapı (24.97 mm), yumurta sarısı indeksi (%43.49) ve Haugh birim (92.77) olarak belirlendi. Kabuk ağırlığı pozitif olarak yumurta sarısı yüksekliği (P<0.01), yumurta akı yüksekliği (P<0.01), yumurta akı ağırlığı (P<0.05) ve Haugh birim (P<0.01) ile ilişkiliydi. Çalışma bulguları; bıldırcınların küçük tabanlı alanda yerleştirilmesinin dış ve iç yumurta kalitesini olumsuz etkilediği ortaya koymuştur. Bıldırcınların kafes taban alanının 200 cm²/bıldırcından daha düşük olmasının ekonomik kayıp oluşturduğu sonucuna varılmıştır.

Anahtar sözcükler: Kafes, Yumurta kalitesi, Kafes yoğunluğu, Bıldırcın

INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) is distributed in many parts of the world, also in Egypt where it could be used as a source of meat and eggs. It has also depicted worldwide usage as laboratory animal [1]. Advantages of Quail as meat animal are: low housing costs and smaller body weight so low floor and/or cage space requirements.

In addition to, outcome of waste is low compared with other conventional livestock enterprises, and thus it is not so detrimental to the environment [2].

Overall egg quality is important for both poultry breeders and for consumers. Poor quality results in substantial economic losses to the worldwide egg industry. For example, losses due to poor eggshell quality have been



İletişim (Correspondence)



+20 122 3668785; Fax: +20 205 52283683



mmohamedibrahim@zu.edu.eg; mahmoudtarabany2887@yahoo.com

calculated to be in the order of 6-8% [3]. The egg industry is more dependent on high stocking densities for laying hens and quails either during the rearing or laying phases as a tool to reduce housing and equipment costs per bird. The much reduction in the available cage floor space per bird, moreover, feeder and drinker space per bird, may have depressive effects on growth and later performance, so feed intake might decrease which had a worse effect on live weight, and muscular and bone development. Body weight and feed intake are key factors in bird development, egg production, egg size and feed conversion [4].

The phenotypic correlation between any two quantitative traits explained the degree to which individuals above average for one trait tend to be above, below or near the average for the other traits [5]. Knowledge of correlations among productive traits is essential for the construction of selection indices designed to maximize the rate of genetic improvement. Phenotypic characteristic for egg quality traits of external and internal type is important mainly for interest of economy of production [6]. The eggs weight is directly correlated with egg shell quality which has a positive correlation with shell thickness and shell weight [7]. Kul and Seker [8] estimated the phenotypic correlation between internal and external quality traits of eggs in quails. Positive phenotypic correlation was recorded between egg weight and other egg biometrical traits. Ayasan et al. [9] demonstrated high feed conversion ratio, live weight and carcass traits in female quails managed at low stocking density.

The economical importance of stocking density comes from its depressive effect on gain per bird housed and too small profit margins as poultry industry depends on intensive production [10]. Therefore, the objectives of the present investigation were to evaluate the effects of cage density on external and internal egg quality traits and to measure the phenotypic correlation coefficients between external and internal egg quality traits.

MATERIAL and METHODS

Experimental procedures were conducted in accordance with the Zagazig University Animal Ethics Committee guidelines (ANWD-206). Two hundred and sixteen birds of Japanese quails at 14th week of age were used with average initial body weight (173.46 g±1.38). The birds were obtained from experimental unit belonging to Faculty of Agriculture, Zagazig University. The birds were divided randomly into three groups, 60, 72 and 84. Each subdivided into 4 replicates, where the cages floor spaces were 200, 167 and 143 cm²/bird; respectively. The measures of each cage were 60 x 50 x 37 cm (L x W x H).

Fourteen hours of light per day were provided for quails to maintain maximum egg production and fertility. Supplementary lighting was provided as required to

maintain the production [11]. Basic quail's diet was provided ad libitum containing 19.5% crude protein and 2852 k.cal ME/kg. The calculated analysis and ingredients of laying diet were demonstrated in Table 1. To assess the egg quality parameters, a total of 240 fresh eggs were randomly collected in 4 sequent weeks, 80 eggs from each stocking density group. Eggs were individually labeled after collection and the following measures of egg quality were taken.

Egg weight measured using the Sartorius 1202 MP balance with accuracy 0.01 g. Egg length and width (mm) measured using an electronic digital caliper. Egg shape index: calculated as egg width/egg length x 100 [12]. Egg shell thickness (mm): measured using an electronic digital caliper, taken as the mean of measures from the equator and both ends of the egg. Egg shell weight (g) was measured, as well as egg shell percentage as shell weight/egg weight x 100. Egg surface area cm²: calculated as $3.9782W^{0.7056}$, where W = egg weight [13]. Egg shell density mg/cm²: calculated as shell weight (mg)/egg surface area [14].

The measurements of the internal qualities were obtained by gently broken the egg using a scalpel and the contents were taken on flat surface. The yolk was carefully separated from the albumen for weighing. The albumen weight was calculated by subtracting the weight of yolk and shell from the weight of whole egg. The albumen and yolk height and width (mm) were measured using electronic caliper [15]. Yolk weight ratio (%) = yolk weight (g)/egg weight (g) x 100. Similarly, albumen weight ratio

Table 1. Diet composition in the laying period

Tablo 1. Yumurtlama periyodunca kullanılan diyetin içeriği

Ingredients	Laying diet
Yellow corn	64.50
Soybean meal (44%)	20.50
Concentrate (52%)	10.00
Di- calcium phosphate	2.31
Limestone	0.96
DL- methionine	0.09
Lysine	0.08
Vitamin and trace mineral	0.30
Premix	1.06
Coccidostate	0.10
Antioxidant	0.10
Calculated Analysis	
ME (K.cal/kg)	2852
Crude protein (cp %)	19.50
Calcium %	2.33
Available phosphorus %	0.66
Lysine %	1.04
Methionine	0.52

(%) = albumen weight (g)/egg weight (g) x 100. Yolk index (%) = yolk height (mm)/yolk diameter (mm) x 100 [16]. Haugh Unit = 100 log (albumen height (mm) + 7.57 - 1.7 x egg weight (g))^{0.37} [17].

Data were analyzed using SAS statistical analysis system package [18]. One way ANOVA was performed using the following model

$$Y_{ij} = \mu + L_i + e_{ij}$$

Where Y_{ij} = egg quality trait; L_i = effect of i^{th} stocking density and e_{ij} = residual. The preliminary effects of replicates were non-significant. Differences among means were compared statistically using Duncan's multiple range tests [19]. Pearson correlations were performed to compute the relationship of the external and internal egg quality traits.

RESULTS

Means \pm standard error of external and internal egg quality traits at different stocking densities (200, 167 and 143 cm²/bird) are shown in Table 2. It clearly shows that different stocking densities had significant effect on most of egg quality traits.

Phenotypic correlation coefficient between external and internal egg quality are presented in Table 3. As it

was seen, there were significant correlations among the different egg quality traits.

DISCUSSION

The primary objective of this study was to investigate the effect of cage stocking density on egg quality traits in Japanese quails and to explore the correlations between external and internal egg quality traits. Birds housed at 200 cm²/bird, cage floor space, recorded significant ($P < 0.05$) higher estimates for egg weight (12.24 g), shell weight (1.27 g), eggshell ratio (10.55%), shell thickness (0.23 mm) and egg shell density (48.70 mg/cm²), compared to birds housed at lower cage floor space (167 and 143 cm²/bird). Results revealed that, stocking density had a non-significant effects ($P > 0.05$) on egg length, where the longest egg length had been measured for quails kept at cage floor space of 200 cm²/bird. Birds housed at 200 cm²/bird, cage floor space, had significant ($P < 0.05$) higher estimates for yolk height (10.72 mm), albumen height (5.67 mm), yolk diameter (24.97 mm), yolk index (43.49%) and Haugh unit (92.77), compared to birds housed at lower cage floor space (167 and 143 cm²/bird). However, results cleared that stocking density had a non-significant effects ($P > 0.05$) on yolk weight, yolk ratio, albumen weight and albumen ratio.

The linear lowering in egg weight with each increase in

Table 2. Effects of different cage stocking densities on the external and the internal egg quality traits of Japanese quails

Tablo 2. Bıldırcınlarda kafes yoğunluğunun dış ve iç yumurta kalitesi üzerine etkileri

Trait	Cage Stocking Density (cm ² /bird)			F	P value
	200	167	143		
Egg weight (g)	12.24±0.16 ^a	11.87±0.12 ^{ab}	11.74±0.14 ^b	3.16	0.04
Egg Length (mm)	33.11±0.19	32.80±0.18	32.95±0.16	0.74	0.47
Egg Width (mm)	25.92±0.14 ^a	25.50±0.15 ^b	26.12±0.13 ^a	4.80	0.00
Egg shape index (%)	78.41±0.48 ^{ab}	77.87±0.55 ^b	79.35±0.38 ^a	2.43	0.09
Shell weight (g)	1.27±0.01 ^a	1.08±0.01 ^b	1.06±0.01 ^b	59.98	0.00
Eggshell ratio (%)	10.55±0.19 ^a	9.22±0.11 ^b	9.16±0.14 ^b	25.91	0.00
Shell thickness (mm)	0.23±0.009 ^a	0.20±0.003 ^b	0.20±0.002 ^b	39.68	0.00
Egg surface area (cm ²)	23.26±0.21 ^a	22.78±0.17 ^{ab}	22.59±0.19 ^b	3.10	0.04
Eggshell density (mg/cm ²)	48.70±0.90 ^a	44.92±0.51 ^b	44.37±0.64 ^b	11.01	0.00
Yolk height (mm)	10.72±0.22 ^a	9.13±0.12 ^b	8.38±0.14 ^c	48.41	0.00
Albumen height (mm)	5.67±0.13 ^a	4.15±0.06 ^b	3.95±0.05 ^b	38.12	0.00
Yolk diameter (mm)	24.97±0.29 ^a	23.86±0.24 ^b	23.58±0.28 ^b	6.99	0.00
Yolk weight (g)	4.31±0.13	4.31±0.13	4.27±0.11	0.03	0.96
Yolk ratio	35.46±1.08	36.57±1.13	36.86±1.01	0.47	0.62
Albumen weight (g)	6.64±0.17	6.41±0.15	6.26±0.15	1.38	0.25
Albumen ratio	53.98±1.10	54.15±1.12	53.34±0.98	0.15	0.85
Yolk index (%)	43.49±1.09 ^a	38.52±0.63 ^b	35.97±0.77 ^c	19.79	0.00
Haugh unit	92.77±0.40 ^a	87.35±0.33 ^b	86.29±0.35 ^c	32.03	0.00

Means within the same row having different superscripts are significantly different

Table 3. Correlation coefficients among the external and internal egg quality traits in Japanese quails**Tablo 3.** Bıldırcınlarda dış ve iç yumurta kaliteleri arasındaki korelasyon katsayıları

Traits	Egg Weight (g)	Egg Length (mm)	Egg Width (mm)	Egg Shape Index (%)	Shell Weight (g)	Eggshell Ratio	Shell Thickness (mm)	Egg Surface Area (cm ²)	Eggshell Density (mg/cm ²)
Yolk height (mm)	0.004	-0.03	-0.026	0.001	0.244**	0.222**	0.314**	0.004	0.136*
Albumen height (mm)	-0.031	-0.091	-0.175**	-0.087	0.371**	0.380**	0.262**	-0.032	0.265**
Yolk diameter	0.356**	0.244**	0.233**	0.00	0.220**	-0.058	0.174**	0.357**	-0.037
Yolk weight (g)	0.237**	0.026	0.132*	0.105	0.007	-0.164*	0.058	0.237**	-0.138*
Yolk ratio	-0.169*	-0.274**	-0.096	0.153*	-0.103	0.024	0.004	-0.180**	0.003
Albumen weight (g)	0.671**	0.579**	0.336**	-0.190**	0.135*	-0.338**	0.046	0.671**	-0.267**
Albumen ratio	0.225**	0.298**	0.108	-0.161*	0.013	-0.144*	-0.011	0.226**	-0.119
Yolk index (%)	-0.172*	-0.155*	-0.139*	0.007	0.119	0.242**	0.206**	-0.181**	0.151*
Haugh unit	-0.121	-0.196**	-0.182**	-0.001	0.311**	0.380**	0.299**	-0.139*	0.255**

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed)

density from 200 to 143 cm² per bird agreed with findings of Faitarone et al.^[20], this can be explained by depression of feed intake and more energy expenditure may be accountable for the reduction in egg weight of quail housed at higher cage stocking density. Davami et al.^[21] concluded that hens in lower density cages were allowed more movement within the cage, which may results in less stressful conditions. Food is portioned between body functions, including maintenance, growth, reproduction and health. In stress, most of the consumed food is used to cope with unpleasant conditions ^[22]. In the present investigation, this condition may explain the reduction in the egg weight in groups with high densities.

High stocking density in the cages makes it very difficult for the birds to dissipate their heat ^[23]. Gou et al.^[24] stated that, birds raised in small group size had a lower rectal temperature than those raised in big group size, indicating a facilitating effect of thermoregulation. The birds tend to distance themselves from one another to maximize sensible heat loss. The reduction in reproductive performance associated with heat stress is a well-known phenomenon in domestic birds. This is probably due to the direct debilitating effect of high heat stress on ovarian function in the birds or indirectly through reduction in blood flow to the ovary ^[25]. Also, Dhaliwal et al.^[26] stated a higher stocking density adversely affected egg quality. Negotiated results were demonstrated ^[27]. They found that albumen index and fresh albumen weight were higher in birds in the lower stocking density than those in other stocking density. On the contrary, non-significant effects of stocking density on egg weight in Japanese quails were reported, and accounted these finding for smaller size of Japanese quails compared to Italian quails ^[28]. Kakimoto et al.^[29] and Bovera et al.^[30] enhances these finding, they concluded that, external and internal quality of egg remains unaffected by group size in laying hens. Nagarajan et al.^[10] reported that shell thickness was influenced neither by age of the hen nor by stocking density, and

the yolk index was superior in the lowest stocking density group. Bandyopadhyay and Ahuja ^[31] added that cage density significantly affected albumen index, yolk index and internal egg quality, but not egg weight, shape index or shell thickness. In general, yolk index and internal egg quality decreased with increasing cage density; albumen index did not show a definite pattern

Egg weight was positively correlated ($P < 0.05$) with yolk diameter (0.356), yolk weight (0.237), albumen weight (0.671) and albumen ratio (0.225). Egg length was positively correlated with yolk diameter (0.244), albumen weight (0.579) and albumen ratio (0.298). Otherwise, egg weight was negatively correlated with yolk ratio (-0.169), due to lower specific gravity of the yolk which has more lipid content. Shell weight was positively correlated with yolk height (0.244), albumen height (0.371), yolk diameter (0.220) and Haugh unit (0.311). Concretely, shell thickness was observed to be correlated significantly with yolk height (0.314), albumen height (0.262), yolk diameter (0.174), yolk index (0.206) and Haugh unit (0.299). Egg shell density was positively correlated with yolk height (0.136), albumen height (0.265), yolk index (0.151) and Haugh unit (0.255). On the contrary, egg length was negatively correlated ($P < 0.01$) with yolk ratio (-0.274) and haugh unit (-0.196). Similarly, eggshell ratio and eggshell density were negatively correlated ($P < 0.01$) with albumen weight (-0.338 and -0.267).

Results regarding the egg weight were positively correlated with yolk diameter, yolk weight, albumin weight, albumin ratio, which are supported by Zita et al.^[32]. They measured positive phenotypic correlations of egg weight with yolk weight, albumen weight and egg shell weight. Also, their finding about negative correlation of egg weight with yolk ratio and egg shell proportion negotiated our experiment. In addition to, positive correlation of egg weight with albumen ratio and negative correlation of albumen weight with eggshell ratio. The findings of

Baumgartner ^[1] and Minvielle et al.^[33] are in the same line with our investigation who estimated high positive correlations between egg weight and the weights of its contents but, Baumgartner et al.^[34] found that the correlations between egg weight and the yolk, albumen and eggshell weight were non-significant, low positive estimates (0.432, 0.438 and 0.234; respectively). Yannakopoulos and Tserveni-Gousi ^[35] demonstrated that egg weight was positively correlated with albumen weight. Kul and Seker ^[6] and Ozcelik ^[36] stated that the increase in the egg weight will result in decreased yolk ratio. Kul and Seker ^[6] reported that yolk and shell ratios negatively correlated with the albumen ratio and albumen index. Ozcelik ^[36] demonstrated that, egg shape index was negatively correlated with albumen weight and yolk weight. We concluded that, housing Japanese quails at low cage floor space associated with depression in external and internal egg quality traits, reflecting the economical hazards of housing quails at cage floor space lower than 200 cm²/bird.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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